

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

*Freshwater Fish in the Waikato Region: An Evaluation of Novel
Standardised Data and Drivers of Fish Distribution and Abundance*



*A thesis presented in partial fulfilment of the requirements for the
degree of*

Masters of Science

in

Ecology

at Massey University, Manawatū,

New Zealand.

Paul Boyce

2016

Abstract

Native freshwater fish populations in New Zealand are in rapid decline and continue to be affected by multiple impacts. As fish populations contract and species become rarer, monitoring and prediction of species presence and abundance throughout New Zealand becomes an increasingly important management tool. Until recently, the majority of modelling analyses in New Zealand have used small or inconsistent datasets which limit analyses to presence/absence type assessments and can make even those analyses inaccurate. Using a novel dataset that was collected using a consistent set of sampling protocols collected by Waikato Regional Council (WRC) staff in the Waikato region, New Zealand, fish presence/absence and abundance data were analysed. Models were built to predict species distributions and abundance across the region and to identify key environmental drivers determining distribution and abundance. Model performance was also assessed in comparison to a commonly used freshwater fish dataset – the New Zealand Freshwater Fish Database (NZFFDB). Drivers of the distribution and abundance of all sampled species were identified and three species were investigated in further detail: longfin eels (*Anguilla dieffenbachii*); shortfin eels (*Anguilla australis*); and redfin bullies (*Gobiomorphus huttoni*). Abundance and distribution predictions were mapped throughout the Waikato region River Environment Classification (REC) waterways for these three species. An analysis of population demographics for redfin bully mean length comparing the east and west coasts of the Waikato region was also undertaken.

Sampling consistency (mean button time and mean area fished) within the WRC dataset was high and model performance was higher for the majority of species using the WRC dataset compared with NZFFDB data. Comparisons between reference and impact sites for the three species revealed significantly higher relative abundance of redfin bullies at reference sites, along with significantly larger longfin eels (subject to methodological bias). Shortfin eel relative abundance was significantly higher at impact sites. A greater proportion of very small and small shortfin eels were caught during sampling with longfin eels having relatively greater numbers in larger size classes. Substantial differences in the size of eels caught using different methodologies were also found with larger individuals caught using netting methods compared with electric fishing. Significant differences in mean length between years for redfin bullies were identified and a significant difference in mean length between east and west coast populations was found. This difference was also present within the NZFFDB dataset.

Distribution and population characteristics for the three species were examined in reference to land use and model identified drivers of variation. Distance, elevation, temperature, and slope

frequently ranked high as drivers of native fish distribution and abundance. Longfin eels and redfin bullies appear to be excluded from areas of intensive agriculture throughout the central Waikato with redfin bullies in particular predominantly limited to areas of remaining indigenous forest cover. This pattern is mirrored by shortfin eels which have high predicted presence and relative abundance values in lowland agricultural areas. Models of native richness and abundance IBI scores also show this pattern of distribution across the Waikato region. Both native richness and abundance IBI scores are higher at the coast where intensive agriculture is absent and a greater proportion of reference sites are available. Scores consistently decrease moving inland towards lowland catchments at a rate that is likely higher than innate species distributions due to diadromy alone.

Predictive modelling for both abundance and presence data provided extensive mapping opportunities for waterways throughout the Waikato region in the River Environment Classification network. This tool used in conjunction with a robust dataset provided a versatile and accurate method for describing fish populations in the region. Many characteristics of the biology and life history of native species were able to be explored within this study, raising questions about recruitment and population biology of fish species, in particular redfin bullies. The importance of establishing consistent sampling protocols throughout New Zealand freshwater monitoring programmes is exemplified in the ability to uncover these characteristics accurately.

Acknowledgements

This thesis would not have been possible first and foremost without the work of the freshwater monitoring team at Waikato Regional Council. Dr. Bruno David, Callum Bourke, Mark Hamer, and many more staff and contributors have collected and continue to collect an immense and comprehensive dataset throughout the Waikato region. The time and effort that has gone into sampling and sample design of this dataset have provided an enormous amount of information about New Zealand native fish. I would like to further thank Dr. Bruno David for his input and guidance in analyses and writing without which the learning curve would have been substantially steeper. Thank you to my supervisor, Dr. Mike Joy for your patience and guidance throughout the project. Sticking with me as I learned has meant a lot and your dedication to freshwater conservation in New Zealand is infectious. Thank you to those who provided financial support which made this whole project possible and thank you to the staff and students of the Massey University Ecology department for your advice and help throughout the project. Finally, thank you to my family, friends, and partner who provided the support and reassurance I needed.

Additional notes and terminology

This thesis is presented as 5 chapters including an introduction chapter. Some repetition is present between chapters in regards to methodologies and dataset descriptions. Where referred to, abundance or count refers to relative abundance (fish/m²). Random and impact are synonymous when describing random sites within the Waikato sampling network. All models within this thesis are cross-validated (cv) using data subsets during model construction (Elith, Leathwick, & Hastie, 2008). Terminology for ROC scores of presence/absence model discrimination (performance) categories is taken from Hosmer, Lemeshow, and Sturdivant (2013). Discrimination categories are as follows; outstanding (ROC ≥ 0.9); excellent ($0.8 \leq \text{ROC} < 0.9$); acceptable ($0.7 \leq \text{ROC} < 0.8$). Waterways within the Waikato Regional Council monitoring network are 1 – 4th order and waterways 5th order and above are grey in modelling maps.

Waikato Regional Council is often abbreviated to WRC and the New Zealand Freshwater Fish Database to NZFFDB. River Environment Classification (REC) network sites used for environmental variable analysis were taken from the REC version 2 dataset available for download from the National Institute of Water and Atmospheric Research¹ (National Institute of Water and Atmospheric Research, 2013).

¹ <http://www.niwa.co.nz/freshwater-and-estuaries/management-tools/river-environment-classification-0>

TABLE OF CONTENTS

i	Title Page	
iii	Abstract	
iv	Acknowledgements	
v	Additional Notes and Terminology	
vii	Table of Contents	
1	Chapter 1:	General Introduction
11	Chapter 2:	Evaluation of Standardised Sampling Protocols from WRC Dataset
27	Chapter 3	Site Characteristics and Fish Species Population Characteristics from the Waikato Region
55	Chapter 4	Predictive Modelling of Fish Populations in the Waikato Region
95	Chapter 5	Spatial Variation in Redfin Bully Length and Abundance: East versus West
119	Synthesis	
123	Appendix A	Supplementary Site Characteristics
131	Appendix B	Supplementary Model Building and REC Data Information
141	Appendix C	Power Analysis of Department of Conservation Freshwater Fish Dataset